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09/936067
JC03 Rec'd PCT/PTO 05 SEP 2001

Process and device for producing components and semi-finished products from synthetic graphite or ceramic granules, in particular for producing graphite tubes

Description

State of the art

The invention relates to a process and a device for producing components and semi-finished products from synthetic graphite or ceramic granules, in particular for producing graphite tubes or a component or semi-finished product made of synthetic graphite or ceramic granules ~~in accordance with the preambles of claim 1, claim 10 and claim 15~~.

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Graphite has very good electrical and thermal conductivity and has a very high level of chemical and thermal resistance. For this reason the material graphite is used, in the form of tubes for example, as a semi-finished product for chemical apparatuses. Tubular heat exchangers made from bundled graphite tubes therefore are known for example.

As graphite is a ceramic material, one of the minor advantageous characteristics of this material is a relatively low resistance to impulsive and dynamic loads, in particular, in order to improve the dynamic resistance of graphite tubes, it was proposed in accordance with DE 31 16 309 C2 to cover the tubes with carbon fibres, the connection with interlocking fit between the tube and the bundles of fibres being produced by means of a curable resin, in a manner similar to a laminate. This process is, however, relatively complex and therefore cost intensive.

the graphite material are reduced without the strength of the material being reduced.

~~According to the invention this object is achieved by the features mentioned in the characterising part of claim 1 and claim 10. Claim 15 relates to a component or semi-finished product produced in accordance with the process of claim 1.~~

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Advantages of the invention

The process according to the invention in accordance with claim 1 has the advantage that owing to the pre-pressing process, as in the case of stamping presses, the graphite particles initially align themselves within the pre-compressed material block transversely to the direction of pressing. Owing to the low flowability of the material to be mixed in the region of the constricted outlet opening of the extrusion press or the extruder upon pressing out, the graphite particles rotate out of their original transverse alignment only by a small angle in the direction of pressing, so that they are arranged substantially obliquely or spirally in relation to the central axis of the finished component.

As the predominant direction of the thermal conduction and resistance properties defined by the alignment of the particles is now no longer purely transverse or purely parallel to the central axis of the pressed component but rather is oblique thereto, a new type of graphite material with substantially lower anisotropy than before results. This is because, on the one hand the obliquely oriented particles have a component transverse to the direction of pressing, which, for example, is favourable for the radial thermal conductivity of heat exchanger graphite tubes

produced according to the process according to the invention. On the other hand, the components of the particles complementary thereto which point in the direction of pressing prevent the bending strength of the graphite tubes being significantly reduced.

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~~Advantageous developments of and improvements to the process described in claim 1 are possible as a result of the measures mentioned in the sub-claims 2 to 9.~~

An embodiment of the invention which is particularly preferred provides for the extrusion press to have a supply chamber with a supply opening for supplying material to be mixed, which supply opening is arranged between a start and an end position of a plunger piston which can be reduced to the size of the supply chamber, the shaping of the material to be mixed comprising the following steps which form a cycle:

a) Metering of material to be mixed into the supply chamber with the aid of a metering device until this is completely filled when the plunger piston is in the starting position,

b) Quasi-static pre-pressing of the material to be mixed in the supply chamber by slow forward movement of the plunger piston in order to align the particles transversely to the direction of pressing,

c) Pressing out of a volume of pre-compressed material to be mixed through the outlet opening, which volume is smaller than the volume originally in the supply chamber, whereby, once the end position of the plunger piston in the supply chamber has been reached, a pre-compressed residual volume remains,

d) Return of the plunger piston to the starting position and metering of new material to be mixed into an intermediate chamber between the pre-compressed

mass of the material to be mixed. This has the advantage that the material to be mixed shrinks less during the subsequent pyrolysis on the one hand, and, on the other hand, is less flowable, so the desired flow hindrance of the material to be mixed is effectively supported by a lower proportion of liquid binding agent and the tendency of the graphite particles to align themselves parallel to the direction of flow, is reduced. During later pyrolysis, the situation where the carbon fibres present in the component resulting from the material to be mixed become ineffectual owing to shrinkage is additionally effectively prevented.

A further development of the process according to the invention provides that the bulk starting material and the binding agent and further raw materials to form the material to be mixed are mixed by a mixer with low shearing effect, for example a tumble mixer or a Rhön wheel mixer. The result is a particularly gentle mixing process, shearing or breaking off of the carbon fibres added to increase the component resistance being avoided in particular. Furthermore, the individual components are mixed particularly thoroughly with the aid of tumble mixers, so no undesired accumulations of carbon staple fibres form.

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Finally, in accordance with one development of the process ~~of claim 1~~ it is provided that the bulk starting material is comminuted and screened before mixing in such a way that it effectively contains a first particle size fraction with particle sizes greater than 0 mm and less than 60 µm and with a material proportion of 20 to 100 wt. % of the bulk starting material, and a second particle size fraction with particle sizes of 60 µm to 750 µm and a material proportion of 0 wt. % to 34 wt. % of the bulk starting material and a

third particle size fraction with particle sizes greater than 750 µm to 2,000 µm and a material proportion of 0 wt. % to 46 wt. % of the bulk starting material. By producing a bulk starting material containing coarser particles, the material to be mixed resulting therefrom is less viscous and consequently a higher level of internal friction is produced during the subsequent pressing process which prevents a rapid discharge of the material to be mixed through the outlet opening of the extrusion press. As a result, the desired pre-compression of the material to be mixed is supported effectively.

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The device ~~in accordance with claim 10~~ has the advantage that owing to the rapid and quasi-continuous refilling potential of the extrusion press by means of the supply opening, smaller quantities of material to be pressed can also be pressed economically with a single piston stroke and consequently pressing can be carried out with forces which are lower compared with the state of the art. An increase in the flowability of the material to be mixed in order to limit the pressing forces is therefore no longer necessary. Rather, in contrast, the flowability of the material to be mixed can be reduced in a concerted manner in order to prevent the formation of a pronounced flow field in which the graphite particles could align in an undesired manner parallel to the direction of flow. Furthermore, the desired particle alignment can be best achieved with a ratio D/d of the diameter D of the supply chamber to the diameter d of the outlet opening smaller than or equal to 2.5, preferably in a range from 0.4 to 1.0.

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~~Advantageous developments of and improvements to the device described in claim 10 are possible as a result of the measures described in the sub-claims 11 to 14.~~

Conventional extrusion presses extend in vertical direction in order to be able to uniformly fill the supply chamber from above with material to be mixed after removal of the plunger piston. In order to be able to press out continuous components, for example tubes, the height of such vertical extrusion presses must, however, be appropriately large.

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In contrast, a preferred development of the device ~~of claim 10~~ provides for the longitudinal extent of the extrusion press is arranged substantially parallel to the horizontal and the supply opening of the supply chamber to be arranged substantially transversely thereto. Owing to the horizontal arrangement of the extrusion press, its height is advantageously slight and continuous components of almost any length can be pressed out. On the other hand, the filling of the supply chamber in the vertical direction ensures that the material to be mixed is uniformly distributed there.

Drawings

Embodiments of the invention are described in more detail in the description below and illustrated in the drawings, in which:

Fig. 1 shows a flow diagram of a part of the production process of graphite components;

Fig. 2 shows a schematic sectional view through an extrusion press according to the invention for pressing material to be mixed in a preferred embodiment with completely filled supply chamber;

Fig. 3 shows the extrusion press of Fig. 2 during pre-compression;